Proposed WDM-Based Wideband Photonic RF Bus For The Navy's AMRFS Architecture

DARPA WDM WORKSHOP
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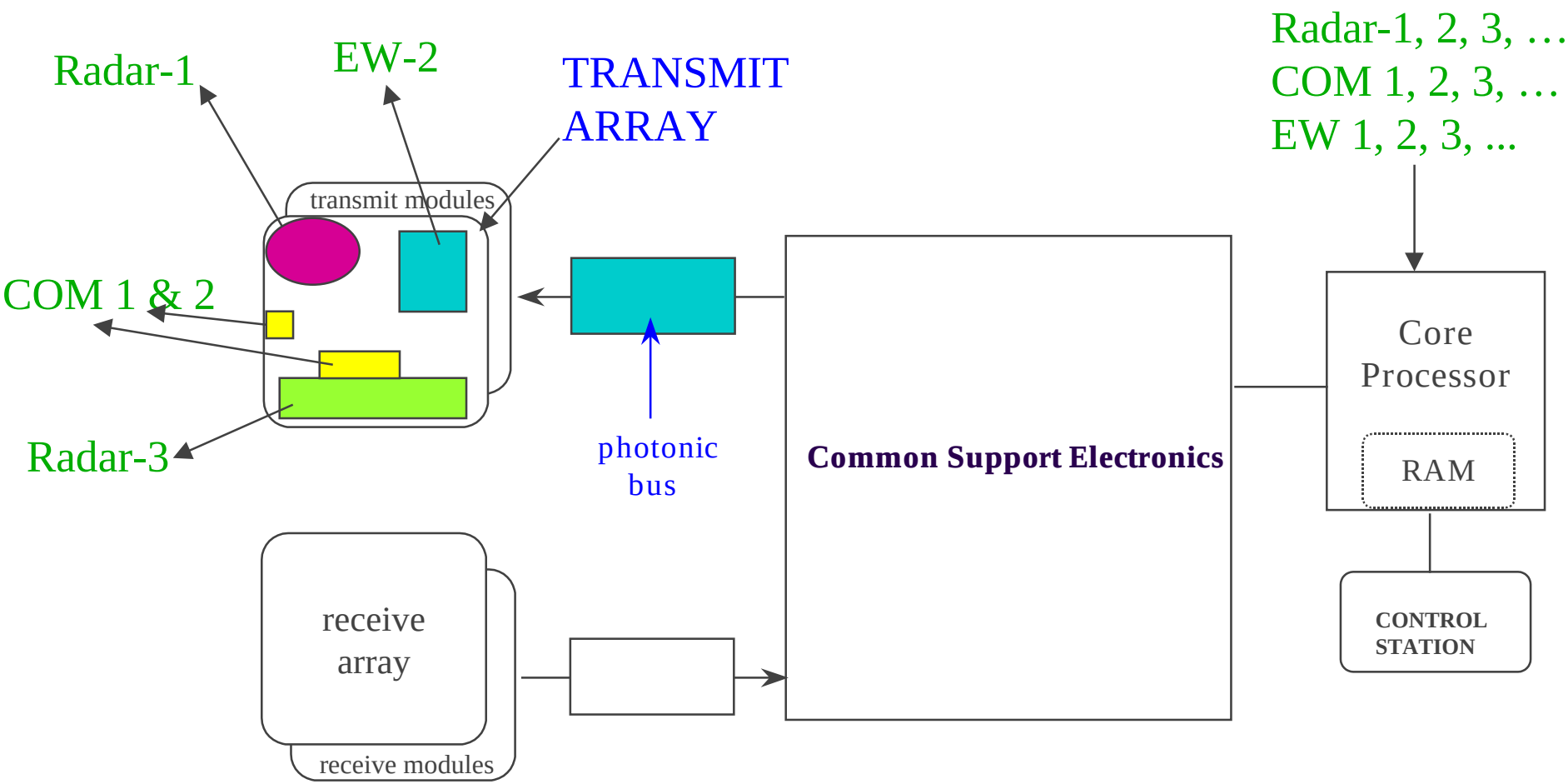
Photonic RF Bus & the AMRFS Architecture



The need for a photonic RF Bus

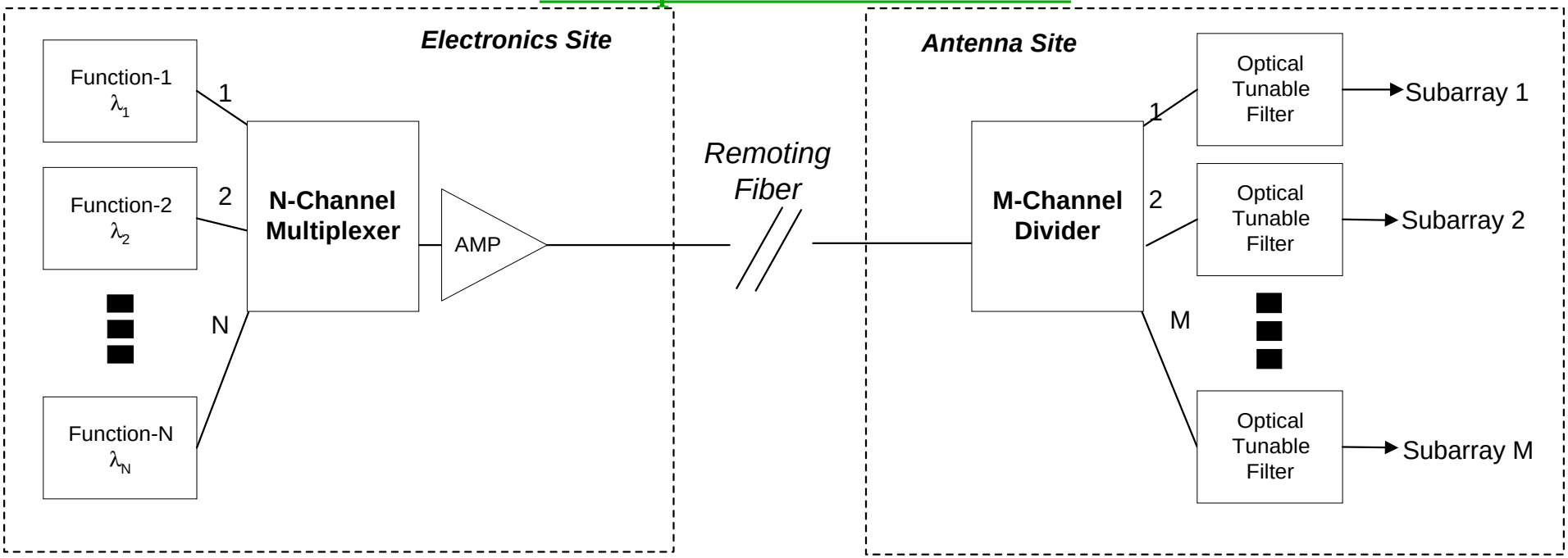
Effective dynamic allocation of wideband multifunction apertures and transmit/receive resources requires an advanced RF interconnection network, with programmable *broadcast, multicast,* and *narrowcast* capability.

Coaxial interconnections are point-to-point with little reconfiguration capability (large number of lines and switches required), are lossy and heavy.

The WDM RF photonic bus offers a wideband, lightweight, fully programmable solution

WDM RF Bus: *Architecture*

Multiplex and Broadcast



PROPERTIES

(+) Single fiber to the antenna site
(+) Single optical amplifier
(+) Expandability is relatively easy
(+) Loss grows slow with M plus fixed MUX loss
L (dB) = -10 log M - L_M

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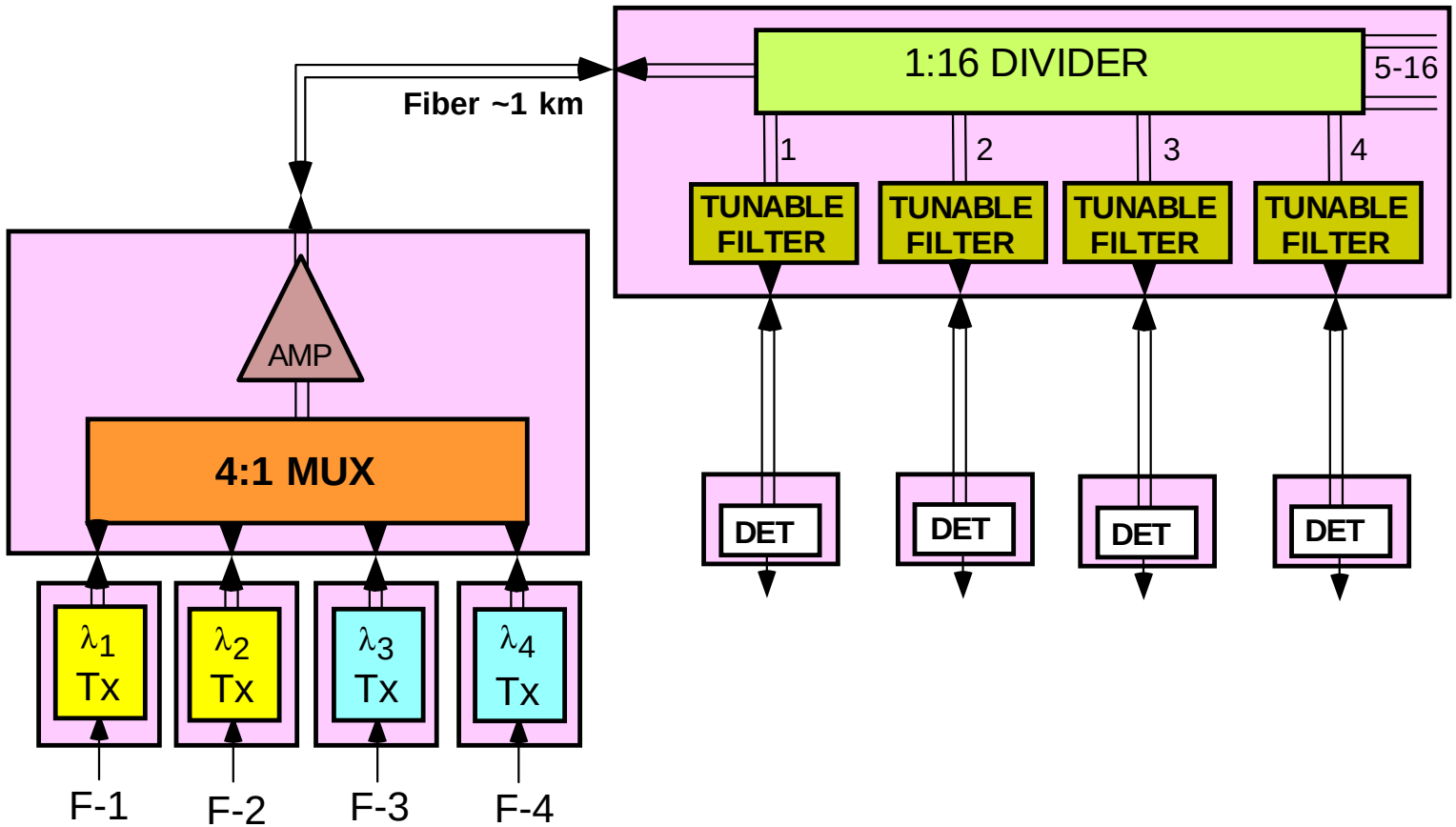
Prototype WDM RF Bus Objectives (1998/1999)

Development and demonstration of a WDM-based photonic RF bus for interconnecting and dynamically allocating multiple subarrays to multiple RF functions.

Prototype bus specs: *4 RF functions, 16 subarrays, operation over 1-5 GHz, SNR > 150 dB/Hz, SFDR > 110 dB-Hz$^{2/3}$*

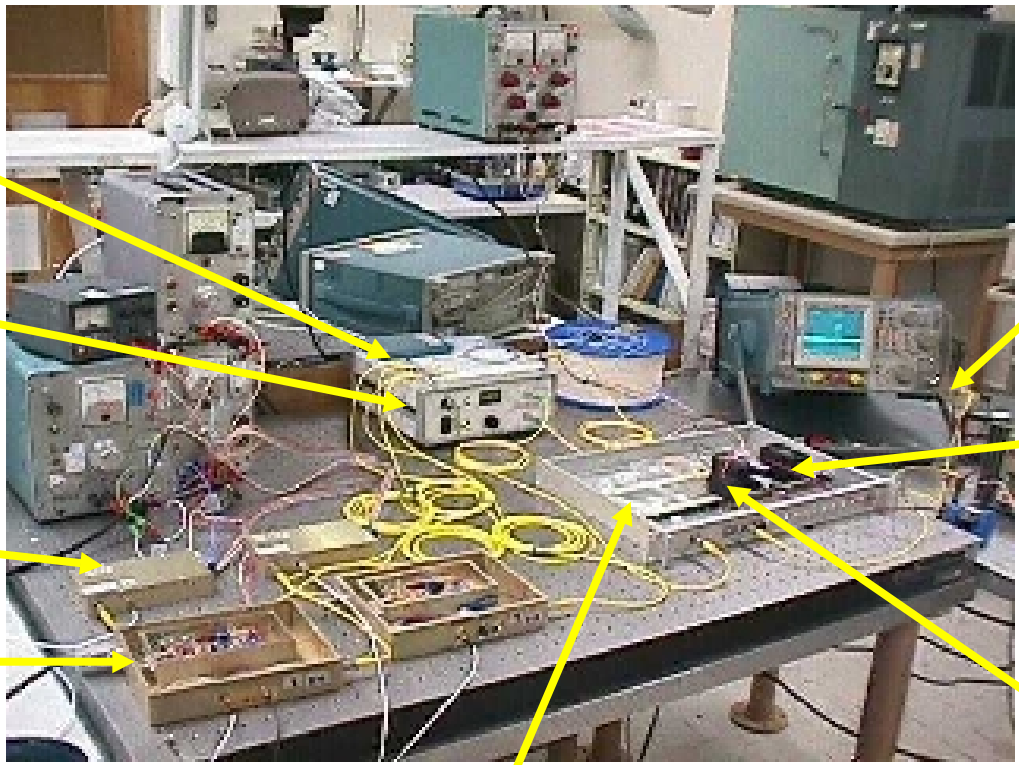
Photonic RF Bus: *Prototype Block Diagram*



Wavelengths (from ITU grid):1542.14 nm, 1546.12 nm, 1550.12 nm, 1554.13 nm

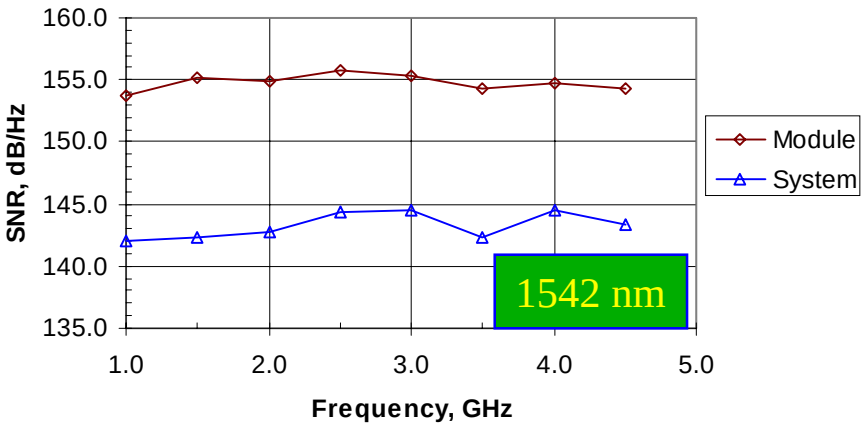
Estimated RF Isolation: > 90 dB

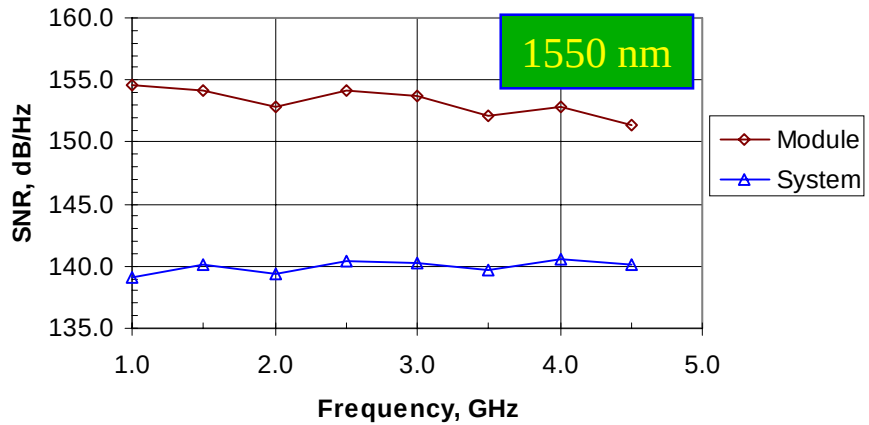
Photonic RF Bus: *Prototype*



Photonic RF Bus: *Measured SNR of the Prototype Bus*

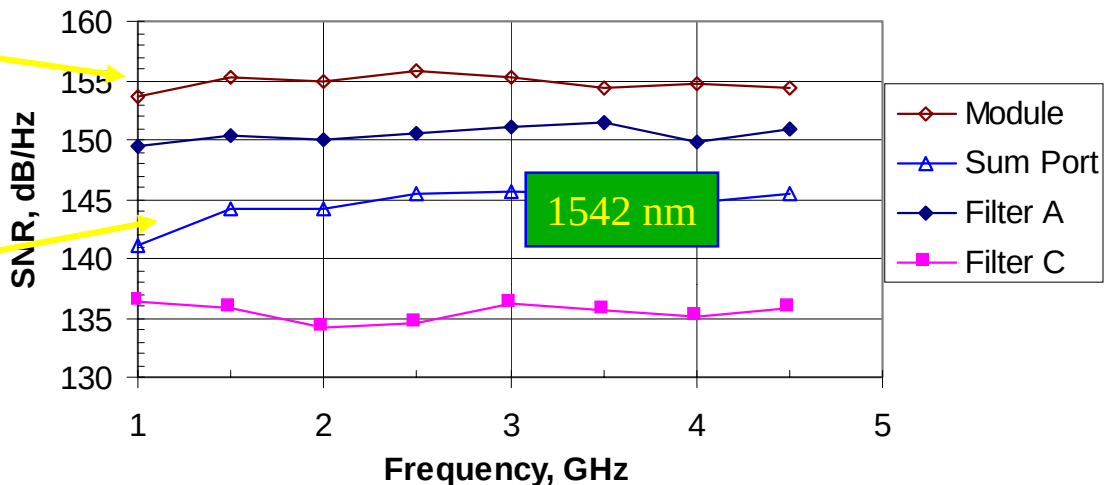
Predicted Average SNR: 141 dB/Hz





O.A. to 1542 nm only

O.A. to all wavelengths



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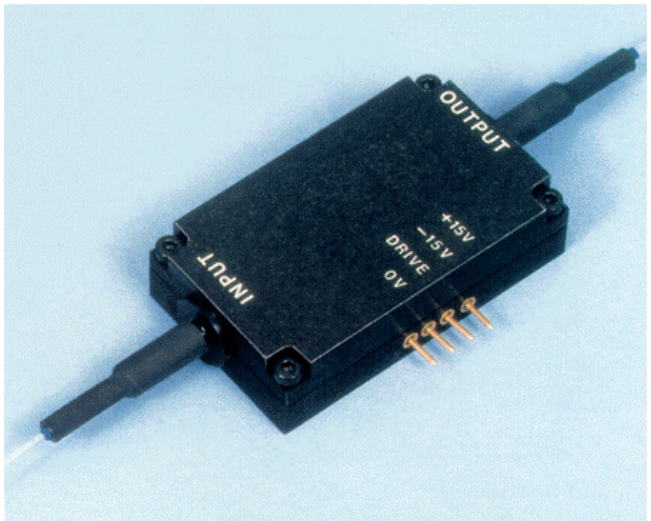
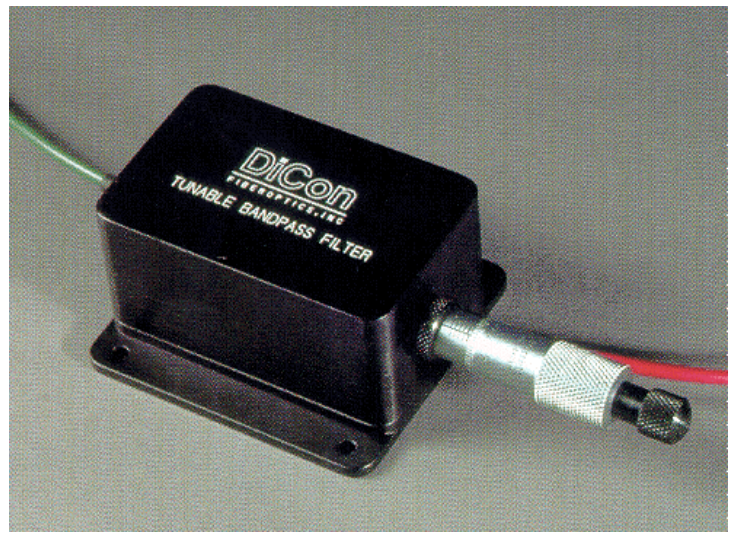
Photonic RF Bus: *COTS Optical Tunable Filters*

QUEENSGATE ($ 5.5 k)



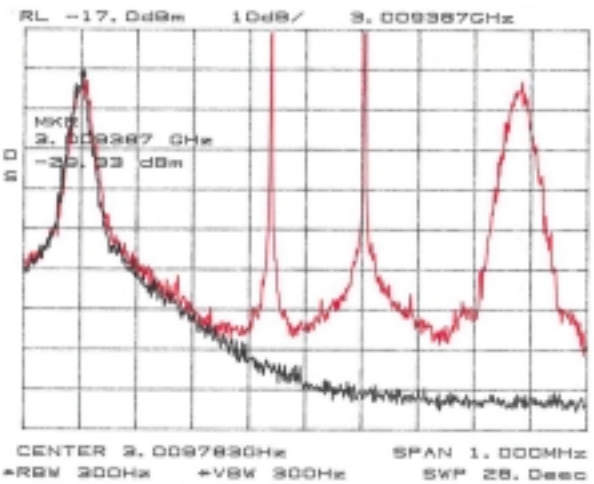
BW: 29.6 nm (vs 14 nm of bus)
3 dB Op. BW: 0.15 nm (18.75 GHz)
IL: 3.0 dB
Speed: 50 nm/ms
Voltage: 0-20 V

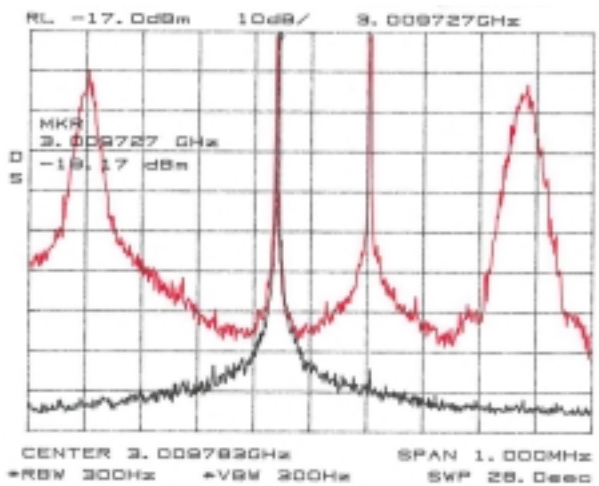
DICON ($ 2.0 k)

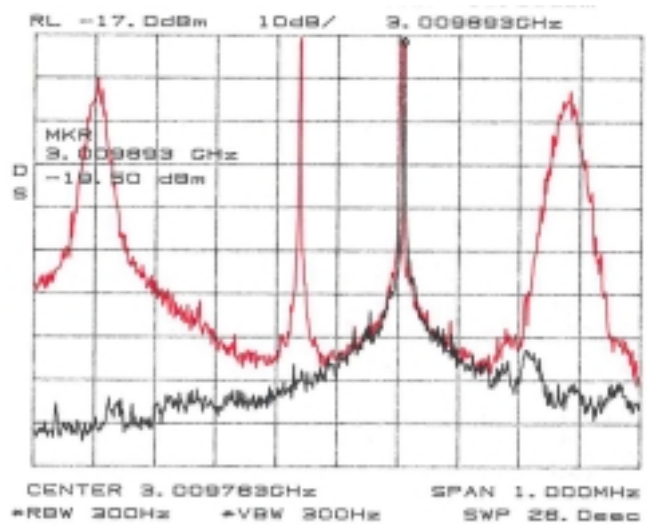


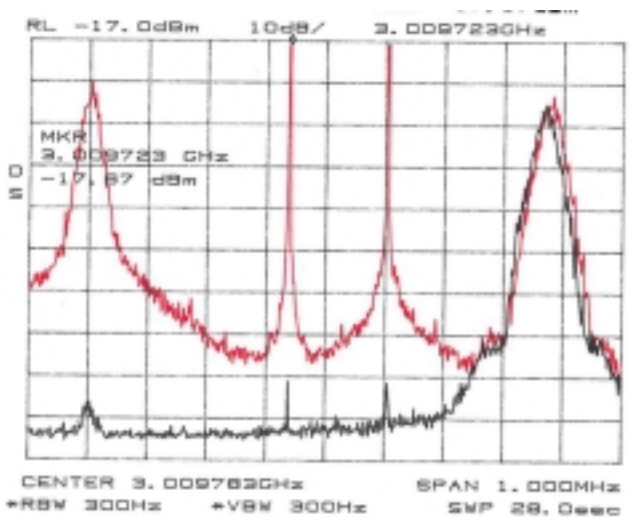
BW: 30 nm (vs 14 nm of bus)
0.5 dB Op. BW: 0.6 nm (75 GHz)
IL: 1.0 dB
Speed: Manual

Photonic RF Bus: *Channel Isolation (Manual Filter)*









Manual Filters (Dicon)

- EMI limited measurements
- Excellent reproducibility

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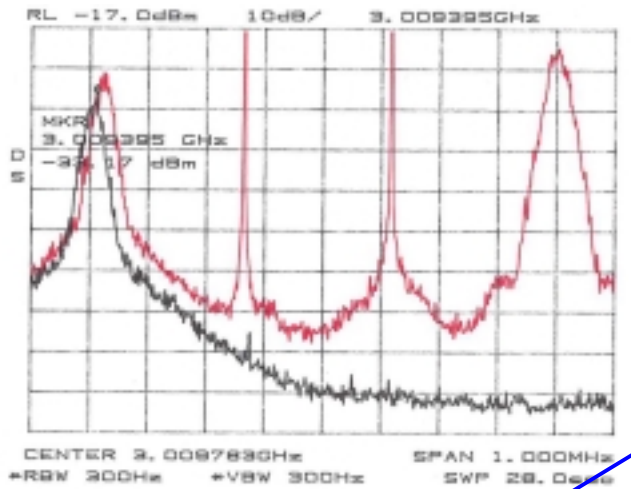
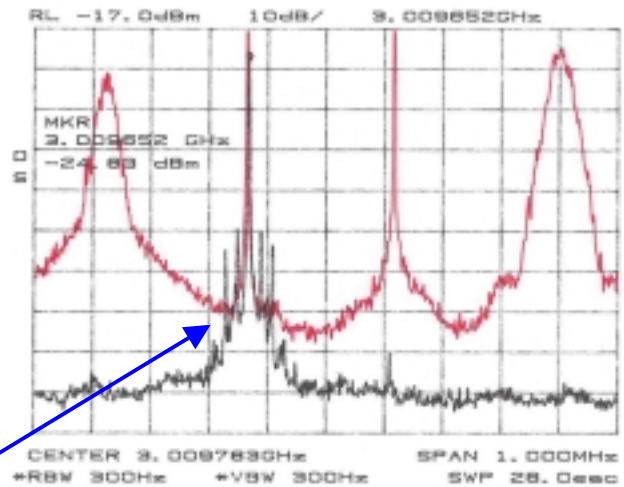
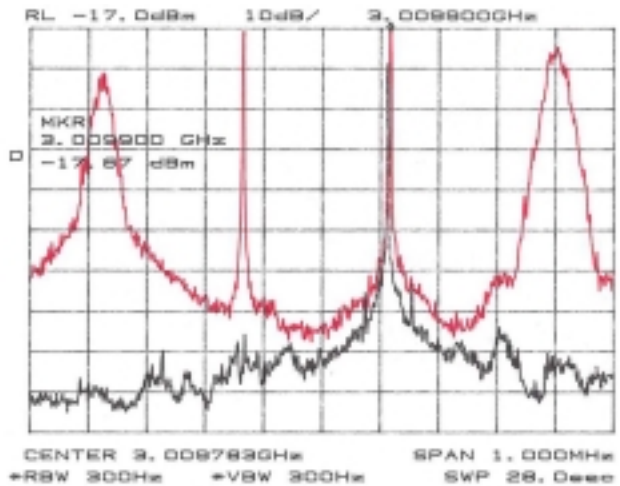
Photonic RF Bus: *Channel Isolation (Electronic Filter)*

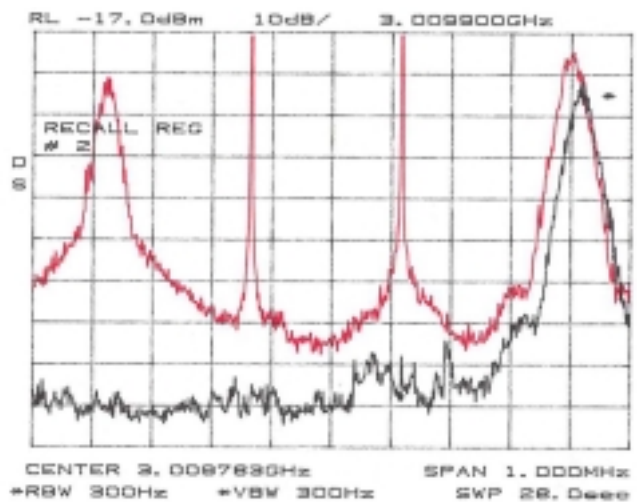






Optical reflections ?

Random generator noise ?



Electronic Filters (Queensgate)

- EMI limited measurements
- Lossier than Dicon's (by 2 dB)
- Strange "spikes"

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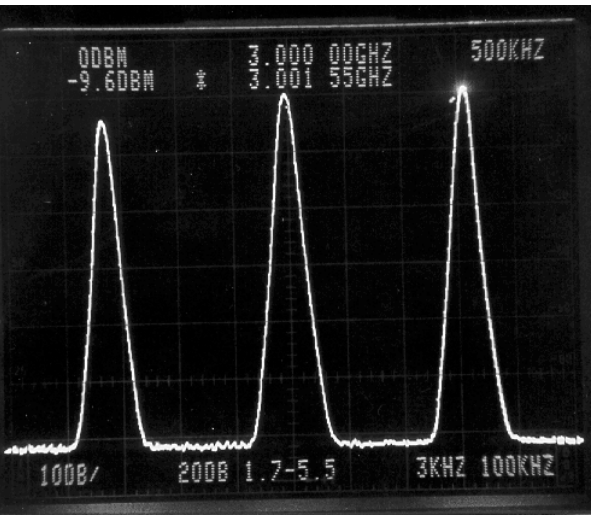
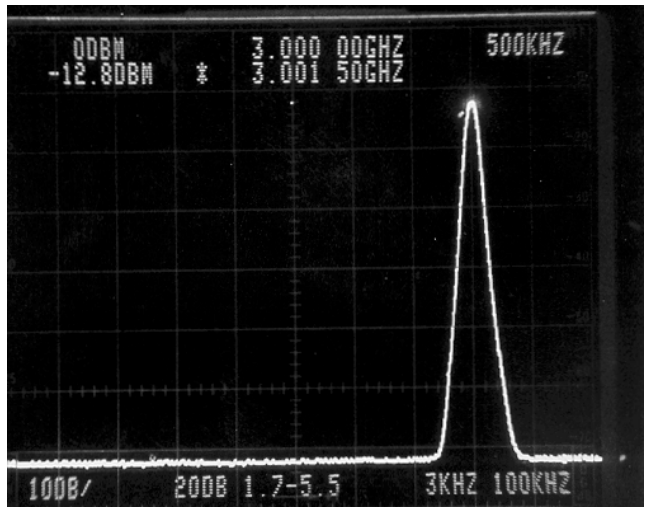
Photonic RF Bus: *Channel Isolation (EMI Isolated)*

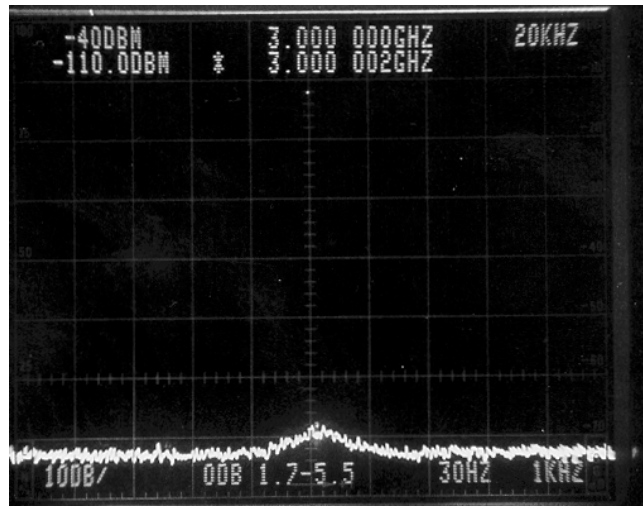
No Filter



Selected Signal



Blocked Signal



Output signal (no filter) = -9 dBm

Selected signal (with filter) = -12.8 dBm

Blocked signal = <-110 dBm

Isolation is better than 97.2 dB

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Photonic RF Bus Prototype: *CONCLUSIONS*

- COTS-based Photonic RF Bus was designed, fabricated and tested. It performed as expected: NO SURPRISES

- Low cost directly modulated links, moderate cost externally modulated links and low cost receivers were developed and performed very well over the 1-5 GHz band
  - Need to know what "type" of link is appropriate for what "type" of function
  - Further improvements possible by matching the link and function RF responses

- COTS passive optical components and COTS optical amplifiers have good performance. No need for custom devices

Photonic RF Bus Prototype: *CONCLUSIONS*

- The optical tunable filters are the key component of the bus.
- The COTS manual tunable optical filters we used performed very well, but are not practical ...
- The electronic tunable filters we used did not perform as well: they were drifting, were lossy, and affected the system Phase Noise

The Photonic RF Bus needs tunable optical filters ...

Desired Optical Tunable Filter Specs

(1) Speed: < 1 msec
(2) Loss: 1-2 dB (Optical)
(3) 0.5 dB Optical BW: 0.6-0.5 nm
(4) Optical Isolation: 50 dB (optical) @ 4 nm from center
(5) Size: not critical (2-3 in^3 is OK)
(6) Cost: ~ $ 1 k
(7) Control: analog or digital is OK
(8) No dithering plates please … they kill the system phase noise.